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REPORT

A traffic information service employing time division multiplex transmission

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Summary

The use of broadcasting to provide traffic and road information to motorists continues to be developed, but there remain several problems. It would seem that a real improvement could be realised if it were possible to provide the driver with a service dedicated to his needs, but which would not overwhelm him with irrelevant data. The shortage of frequencies and other problems complicate the provision of such a system, but investigation suggests that a solution is possible if time-division-multiplex operation is used in the transmission of the announcements. A network of low-power transmitters, each having a range of about 30 km, could operate on a single frequency, co-channel interference being avoided by ensuring that simultaneous transmission by stations within range of each other was prohibited. Thus, each station would only transmit for short periods, during which it would radiate local traffic announcements.

The use of a single frequency means that the car receiver could be of simple design. It would not require tuning by the driver. To ensure that only information from the local station was received, a muting circuit in the receiver would operate at a pre-set field strength level, so that when the car had moved beyond the range of a particular station, it would no longer receive information from that source.

The feasibility of the proposal depends upon several factors, some of which are beyond the scope of work normally undertaken in connection with broadcast research. The work so far carried out is described in the report, and the need for further studies is discussed.

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Introduction

Broadcasting is one way of providing the motorist with traffic information, and for many years the BBC has included traffic announcements in its national programmes. Recently an additional outlet for this purpose has been realised by the introduction of local radio, which provides motorists in the areas served by these stations with local information. However, despite considerable dedication and effort by those concerned the present methods are not completely satisfactory. Reasons for this include:—

(i) The majority of listeners are not immediately concerned with motoring, and can be annoyed by traffic announcements.

(ii) Motorists may be compelled to listen to a particular programme in the hope of receiving useful information.

(iii) There is no clear indication to the motorist which channel may be the best source of information.

(iv) Programme authorities do not always welcome the intrusion of traffic announcements.

(v) To avoid overloading the programme only a fraction of the information available can be transmitted in some busy areas.

(vi) The number of motorists reached is comparatively small (at peak rush hours about 300,000 drivers may be listening to the appropriate programmes — representing about 15% of those on the roads).

(vii) The chance of a particular motorist hearing relevant information is remote.

(viii) In the absence of nationwide machinery the value of the service often depends upon local arrangements, thus the standard varies across the country.

If any new proposal is to succeed the problems outlined above must be reduced. Furthermore, it must be recognised that within the space of the next decade other non-broadcasting techniques for communicating with the motorist may come into operation. Thus it is important that the contribution that can be made by broadcasting should be established as soon as possible in order to avoid wasteful duplication.

A system developed in West Germany* uses a network of transmitters in the Band II broadcasting band (nominally 87·5 — 104 MHz in West Germany but currently 88·1 — 97·4 MHz in the U.K.) to provide the service. Traffic announcements are transmitted by frequency modulation of the main carrier in the usual way, and a subcarrier is used to carry various identification signals. This system has disadvantages, not least being the need to set aside for the traffic service a band of frequencies sufficient to carry a programme with national coverage — e.g. BBC Radio 2, Radio 3 or Radio 4.

This report describes an alternative proposal for a new service that would carry only traffic information, would operate on a single frequency and would require little effort and minimum expenditure on the part of the motorist.

The report is divided into five main parts. Following a brief outline, the second section deals with the programme requirements, i.e., the input of traffic information. The third describes proposals for the transmitter network and discusses methods of operation. The fourth section deals with the receiver, and the report concludes with a general discussion.

1. Outline of the proposal

In addition to recognising the problems in the present arrangements, other important objectives were borne in mind in preparing the proposal. Firstly, it was felt that any system must be cheap, both for the transmitting authority and for the motorist. Secondly it was considered important to ensure that the system should require the minimum action on the part of the driver to receive the messages. It was also clearly important that any new equipment needed in the car should not interfere with any existing radio receiver (apart from the period when traffic announcements were being made). Finally, reception quality would have to be adequate for speech communication.

Consideration of many of the problems led to one inevitable conclusion: the only satisfactory solution required a dedicated service, i.e. a channel devoted solely to the transmission of traffic information. If traffic information is inserted into a normal programme it may have to wait for a gap unless it is regarded as very urgent; indeed, even when it is transmitted it could be missed by a driver whose attentions are elsewhere. A dedicated service — essentially a distinct and separate programme — also offers the advantage of setting up new and efficient machinery for dealing with the reporting and processing of data on a nationwide scale, an important deficiency at the moment. Nevertheless a dedicated service must not be a continuous stream of instructions, which would soon overwhelm the majority of drivers. This state of affairs may be avoided by ensuring that the information received at any one point relates only to a sufficiently small area, so that announce-

* Rundfunktechnische Mitteilungen, Vol. 18 (1974) No. 4 pp. 185 — 192 by Rolf Netzband and Ernst Jürgen Mielke.

ments are not too frequent. Moreover, each announcement is most likely to be relevant to the needs of a particular motorist if it relates to a small area in his vicinity.

An immediate obstacle to the introduction of any new broadcasting programme is, of course, the shortage of frequencies. In the case of traffic information, however, as mentioned above, a continuous output is unlikely provided the area covered by a particular source is small. Thus it is possible to plan in terms of the sequential use of a frequency, i.e., time division multiples (TDM). Using this approach, substantial area coverage of the United Kingdom can be achieved using about 70 low-power transmitters, each having a service range of about 30 km. Employing a single frequency, each would be allowed a short operating period to transmit its local information, and mutual interference would be avoided by ensuring that stations within interfering range of each other did not operate simultaneously. Such a system could be operated automatically, observing a pre-determined sequence, or announcements could be directed to specific transmitters selected by traffic control centres.

The receiver need only be a simple fixed-frequency device. Although information from adjacent service areas would be useful in certain cases, a limit would be imposed. To achieve this a mute in the receiver would operate at a pre-set field strength to ensure that information from only the local station, or possibly an adjacent station, would be heard.

2. The programme requirements

2.1. General

Usually the programme material which is to be transmitted on a network is only of passing interest to the engineer planning the technical characteristics of the stations which will transmit the service. The type of modulation will influence the protection ratios, but the planning assumes continuous operation of the stations. For a TDM network, however, the operating periods are of vital importance to the planning engineer who must be aware of the full requirements. Thus, in this case, it has been necessary to assess both the type and quantity of traffic information which must be handled. This has not been easy (for reasons which are given later), and it is accepted that expert advice — which hopefully will be forthcoming — may result in modifications to the proposals. However, it is hoped that this intrusion by amateurs in the field of traffic information will ultimately lead to a feasible solution which will meet the requirements.

At the beginning of the investigation approaches were made to various police forces and committees, to the Transport and Road Research Laboratory, to certain Universities dealing with traffic studies, and to the BBC's own motoring specialists. Many of the responses were helpful, but because the facilities provided by the BBC proposal were new, the type of information required to satisfy certain queries had never been established. It was therefore decided to obtain the required information by analysing data supplied by the BBC Motoring Unit. These data, mainly derived from police sources, identify the day-to-day incidents which occur on roads within the United Kingdom. However, it was recognised that the information was biased and incomplete. Firstly, the police only pass that information which they think the BBC can handle under present conditions. Secondly, the information relates mainly to rush hours and to certain types of road, so that conditions at other times and in other places are difficult to assess. Nevertheless, the use of other published reports on traffic statistics together with estimates about the amount of additional data which could usefully be transmitted have allowed forecasts to be made.

It is emphasised that only a small part of the work to far carried out is reported here. At this stage the main concern has been to investigate the feasibility and usefulness of the proposal. If this proposal is accepted further work will be required, and it is believed that the preliminary work will provide a very useful basis.

2.2. The nature of traffic information

For some time now it has been the practice to divide traffic information under two main headings — strategic and tactical. These describe respectively, predictable conditions causing delay, and emergencies such as accidents which could result in both delay and more serious complications. The terms are not completely satisfactory, in that they are not exclusive, but the important factor which separates them is time. The predictable effects of strategic information often allow some time to elapse before communication with the motorist becomes necessary. For this reason it is possible to put strategic announcements into a scheduled programme. On the other hand, tactical information is often very urgent and no delay can be tolerated. Here it must be observed that even if instant communication with the motorist is possible from some control centre, some time will inevitably elapse before the incident is reported to that centre. At present, and for the foreseeable future, the 'reporting' time is a variable factor, but obviously it is important when considering the value of any transmission system. Fortunately, the great majority of information which would need to be handled by a broadcasting system does not present the unhappy choice between instant communication or a serious accident. Whether or not the few that do could ever be usefully handled by a system such as that now proposed will largely depend on the reporting system which would have to be built up.

The effects of various types of traffic incidents, and hence the value of information describing these, can be assessed. Factors which influence the number of traffic incidents, and their seriousness once created, include:—

(a) Density of traffic

(b) Type of road, width, etc.

(c) Type of urban development

(d) Weather

(e) Time of day

(f) Time of year

(g) Type of traffic

(h) Speed of traffic

(i) Local events

(j) Traffic control systems

It is quite feasible to predict the effects of many of the factors in this list and to devise a dynamic traffic control system which will minimise the effect of any incidents. Indeed the Metropolitan Police, for example, operate a computer-controlled system which does this very efficiently, but what is lacking is a means of passing information to the motorist in order to keep him informed and to secure his co-operation. In pursuing a plan for traffic information broadcasting, therefore, it is seen as a component of an overall system. It is important to ensure its full integration with other techniques which are being or will be used to smooth the traffic flow.

2.3. Analysis of BBC traffic information

The primary objective was to estimate the amount of programme time which would be required to provide a full motoring service. Clearly the amount of information will depend on the area covered, and initially the investigation was concentrated on the situation in South-East England. At present, traffic information is transmitted on the national networks Radios 1, 2 and 4, and by local radio stations. Because the data were available in an assimilable form, information from the central Motoring Unit only was eventually used for the detailed analyses, but the contribution made by local radio is also very important and this was taken into account. Appendix 1 gives some information regarding the output of three of these stations in the London area.

The Motoring Unit handles many thousands of national announcements per annum. Appendix 2 shows a listing of the announcements for a summer month (July 1974), revealing an average daily rate of about 30.

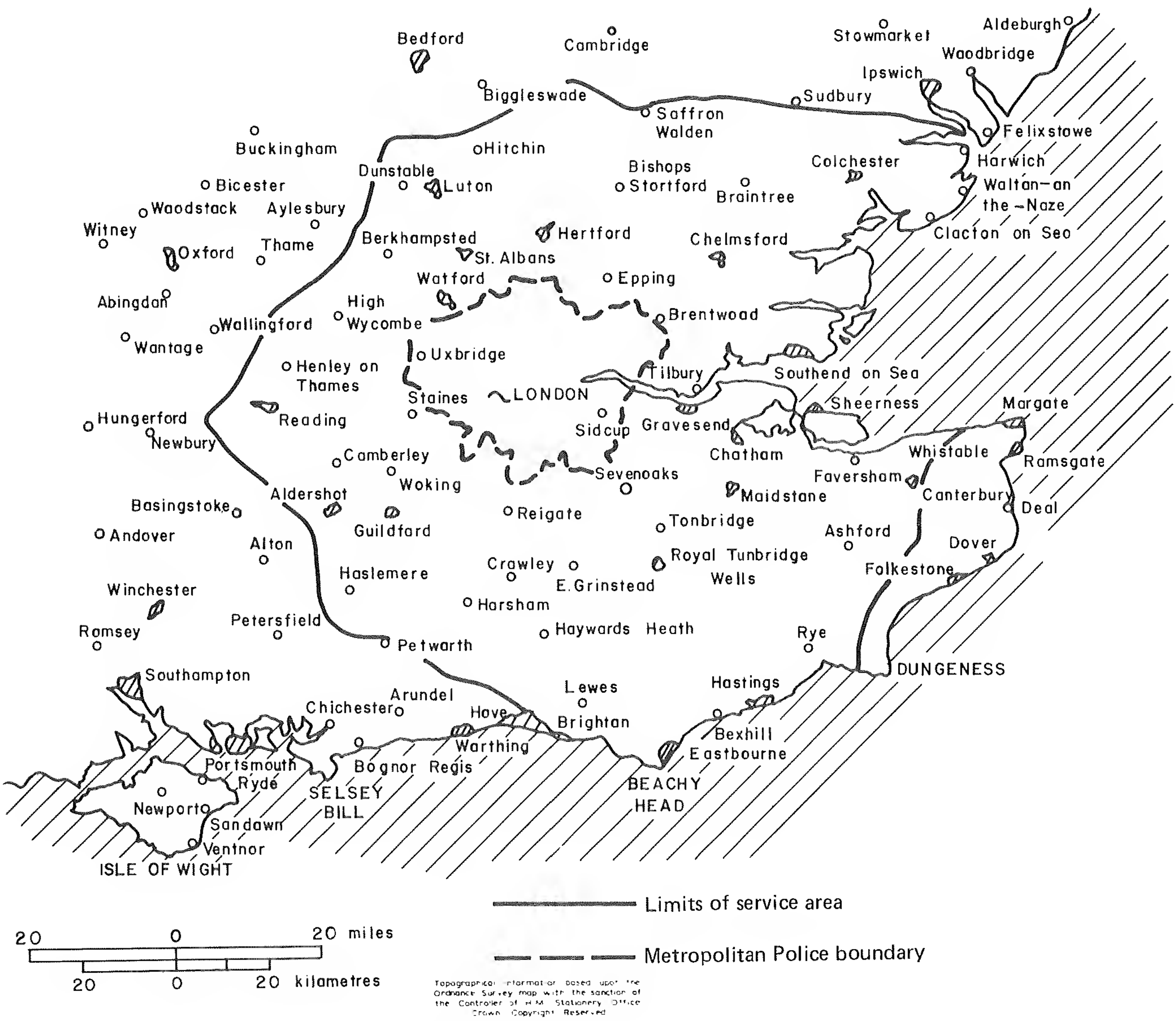


Fig. 1 - Approximate limits of the area within which the Wrotham Band II service is used

As mentioned above, it was decided to concentrate the preliminary study upon South-East England. It was felt that as well as providing adequate evidence for the main investigation, the study should also allow the application of the German proposal to be tested. For this reason the situation inside the service area of the Wrotham Band II station is being analysed. This area is shown in Fig. 1. It covers the busy Metropolitan area, and the road census results for 1972 shows that it embraces about 28% of the total road traffic of the United Kingdom. It contains about 10,000 km or roads, classified as follows:—

Motorways	285 km
Dual-carriageway main roads	550 km
Single-carriageway main roads	5,800 km
Secondary roads	3,500 km

The statistics of the Motoring Unit's announcements, together with other information, are still being studied, but so far the following facts have emerged.

(i) Over a period of 70 days, scattered throughout the year, the number of daily announcements averaged 20. These included some repeats, but weather forecasts are excluded.

(ii) The average duration of each announcement was 16 seconds. More than 99% of the announcements would have been completed if a period of 30 seconds had been allowed to each.

(iii) The ratio of strategic to tactical announcements was 2 : 1.

From this basic information and ignoring other factors it will be seen that the broadcasting time required for the present service, if it were confined to a single channel would amount to not more than 10 minutes per day. If local weather forecasts are included, then the maximum time needed might amount to 15 or 20 minutes. However, there are two other factors which must be taken into account. Firstly, as has already been mentioned, the present service only broadcasts a part of the information which probably should be transmitted, if facilities were available. Estimates from the police and from the BBC suggest that about 75% of the incidents are not announced, either because time cannot be found for them or because the present arrangements are inappropriate. Secondly, there is a considerable amount of data which has not yet been analysed, which is transmitted by the local radio stations in the area (London, Oxford, Medway, Brighton and Solent). The daily output of traffic information from

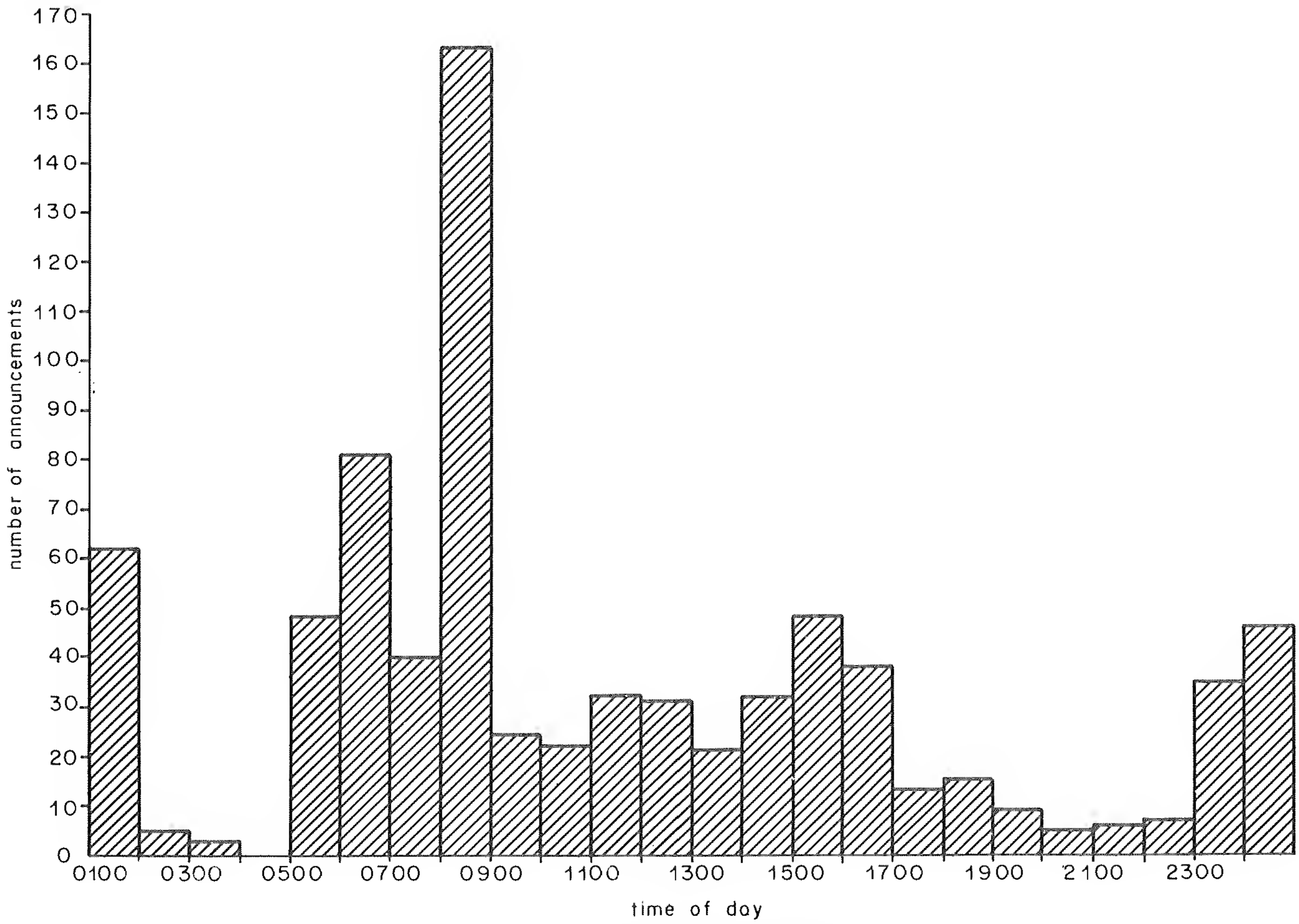


Fig. 2 - Distribution of announcements passing through Motoring Unit as a function of time of day. Total of 785 announcements for a period of 30 days.

some of these stations amounts to nearly one hour of broadcasting time each.

An additional complication which must be taken into account is the rate at which announcements need to be made. This is variable; Fig. 2 shows the number of traffic announcements passing through Motoring Unit for a period of 30 days, plotted as a function of time of day. This does not illustrate the actual occurrence of incidents, firstly because some programmes transmit more traffic information than others, and secondly because much of the strategic information arrives early in the day. However, it does confirm that frequently about one-fifth of the traffic announcements for the day materialise between 0800 and 0900.

From the evidence so far studied, it would seem that if a full service for motorists had to be provided from the Wrotham station to the present service area limits, then allowance would have to be made for between 300 and 400 announcements per day. This would require between one and a half and three hours of broadcasting time on a single programme. At busy periods, in order to avoid delay, it would be necessary to overlap into a second programme.

It can rightly be argued that the Wrotham area is not representative, because alone it embraces more than a quarter of the nation's traffic. This is true, but if any new system were to be introduced, then certainly it must be capable of meeting the load presented in South-East England. Furthermore, the traffic problems elsewhere in the U.K. can be just as severe, although the concentration is lower. In large service areas, such as that produced by the Holme Moss station, the likely demand on broadcasting time could certainly equal that at Wrotham during certain periods. Although the percentage of U.K. traffic in the Holme Moss area is only 11% (compared with 28% in Wrotham), many major towns are covered, and the peak demand would be considerable.

It should be noted at this point that in the foregoing only local information has been considered. There would, in addition, be some generally strategic announcements of national interest for long-distance drivers, but it is assumed that these could be handled in scheduled programmes on a national network.

Clearly, the load estimated above would be too much both for the programme authorities, and for the motorist. Even if it could all be transmitted, the motorist could not possibly absorb such an output. Furthermore, although it is referred to as local, it is only local in the context of the service area. If the latter is large, then much of the information would still be irrelevant to particular motorists. This problem can be overcome by reducing the size of the service areas, and by allowing local information to be inserted at each station. In this respect local radio can offer real advantages. The TDM proposal offers still greater benefits, and these can be seen by comparing the Wrotham situation with a TDM network for South-East England.

Eight TDM stations would be needed to cover the area, although a smaller number would result if there was freedom in site selection (at this stage it has been assumed that for reasons of economy in both implementation time and expenditure existing BBC sites could be used). Using the data resulting from the analysis of the 70 days' output from the Motoring Unit, the daily number of announcements which might have to be dealt with by each station is shown in Table 1.

TABLE 1

Station	Announcements
Medway	100
Tatsfield	60
Manningtree	30
Brookmans's Park	70
Guildford	60
Brighton	50
Bexhill	30
Folkestone	40

The total number of announcements shown (440) exceeds the total for Wrotham alone because duplication is necessary in certain cases. Furthermore, stations serving the periphery of the area would need to have a higher allocation than that shown in the Table because they would also need to cover country outside the Wrotham area. However, it will be seen that providing reception is largely confined to the local station, there is a significant reduction in the number of announcements heard by individual motorists. Furthermore, the chance of the information being relevant is considerably increased. Whilst considering the demand, it is pertinent to note that in the case of the busiest station (Medway), the peak load for the period examined amounted to 16 announcements per hour. Thus the demand here for broadcasting time between 0800 and 0900 would be met by a maximum allocation of up to eight minutes.

3. The transmitter network

3.1. Fundamental requirements

It is proposed that a suitable traffic information service could be achieved by a network of stations each having a service range of about 30 km. Assuming this range, several transmitters would have to operate simultaneously to make efficient use of any channel allocated. To permit this, the network would be divided into a number of groups of stations, and within each group simultaneous transmission would not be permitted. The size of the theoretical lattice embracing each group of stations is dictated by the interfering range. Previous investigations have already shown that a lattice containing 16 stations in each group would be the most suitable way of covering the United Kingdom. A minimum interference distance of 170 km would then exist between simultaneously operating transmitters which would go to make up a time division multiplex network. Fig. 3 shows a theoretical lattice network with transmitter separation of 50 km (service radius 30 km). If an automatic switching sequence were used in

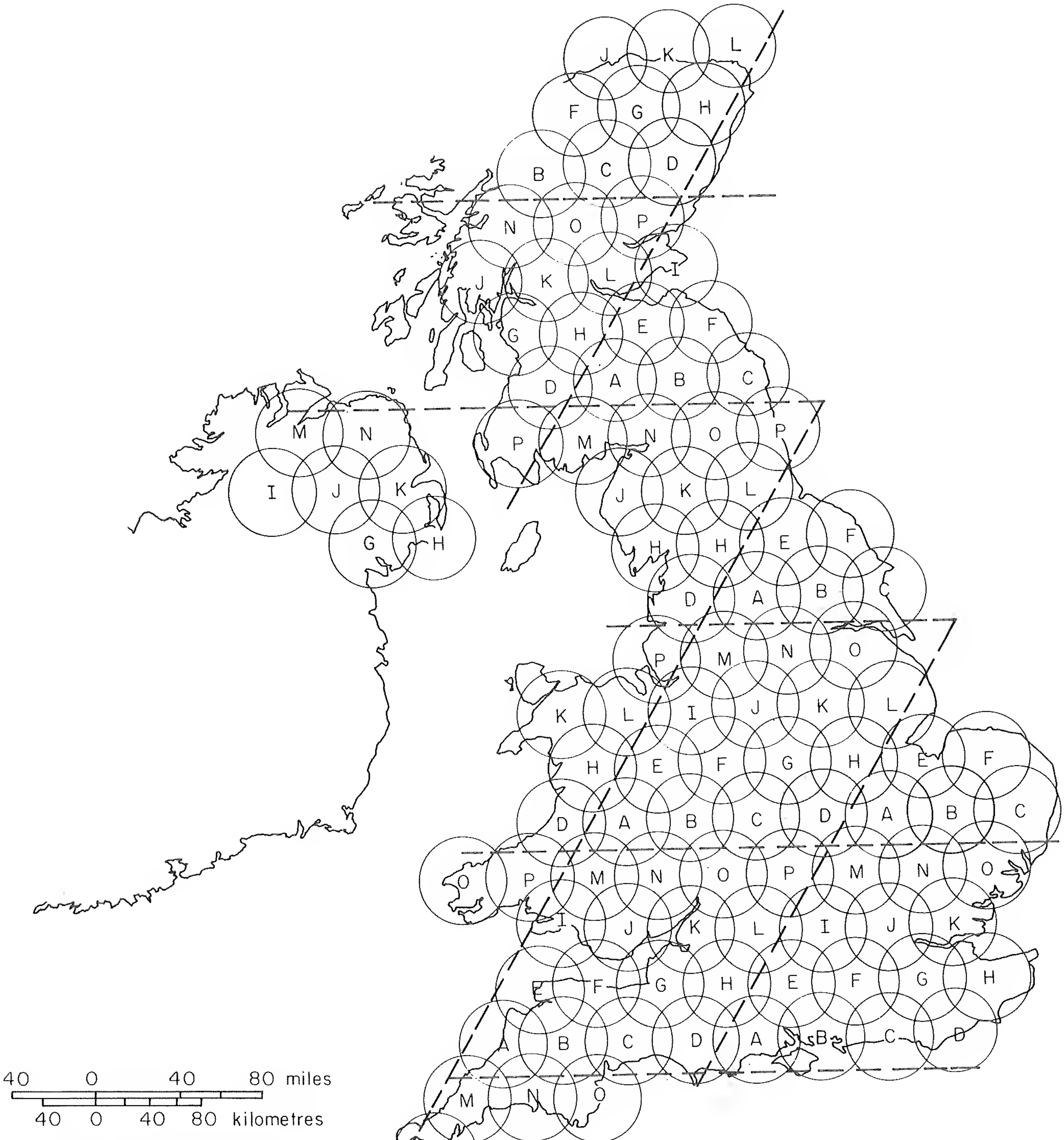


Fig. 3 - Theoretical lattice for groups containing sixteen stations

Simultaneous transmissions occur between stations having the same identification letter

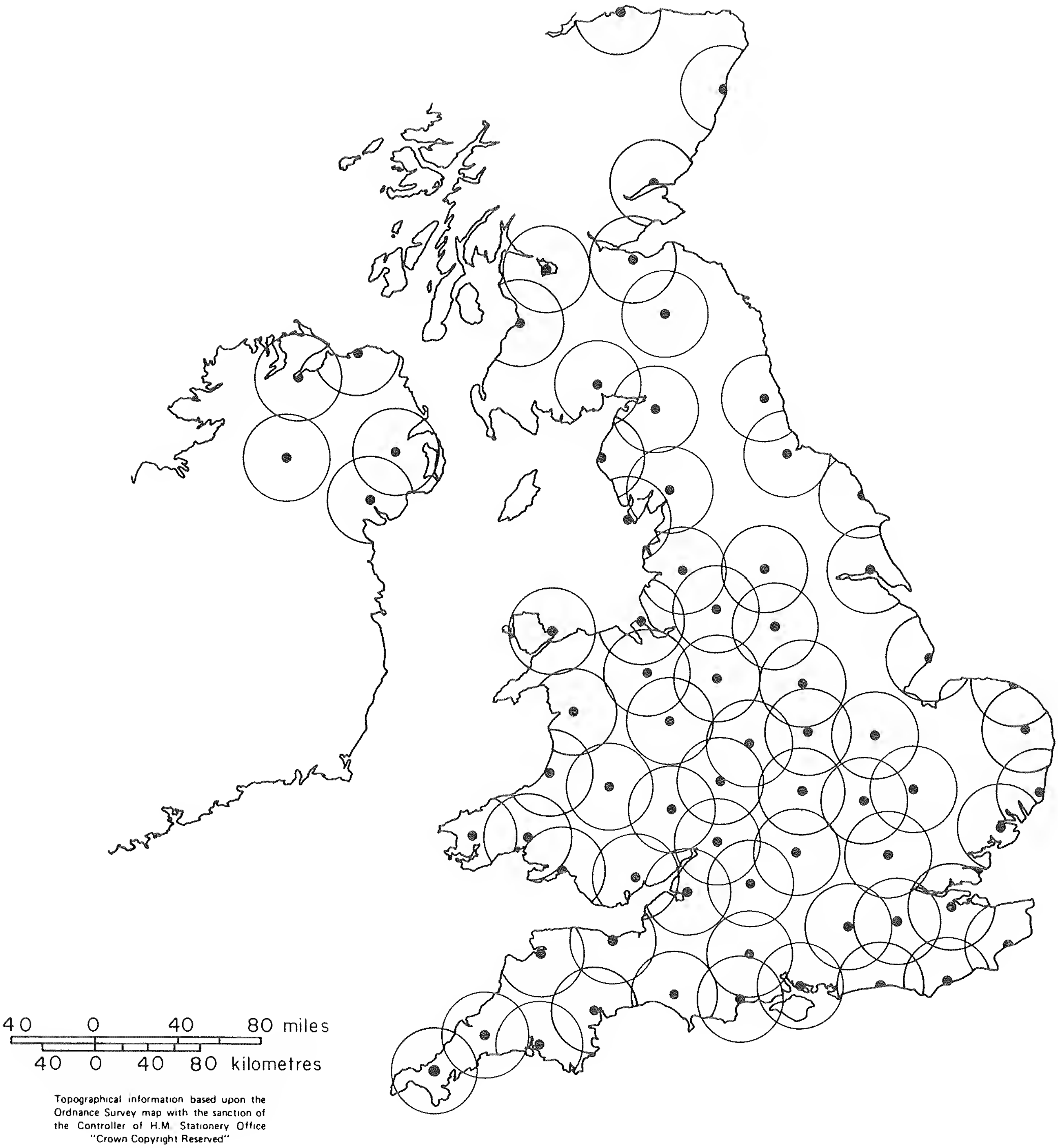


Fig. 4 - Possible network of traffic information transmitters using 72 existing BBC sites

such a system, each station could be allocated a time slot of, say, 30 seconds for its announcement in a cycle period of 8 minutes. In Section 2.3 it was stated that at peak hours the busiest station in the London area might be asked to radiate 8 minutes of announcements in one hour, whereas if all 16 stations in a group were to share the time equally, each could transmit for only 3¾ minutes per hour. It would therefore be necessary to radiate less than the desired number of announcements in a peak period, unless it proved practicable to divide the time unequally between stations. Methods of operation are discussed in Section 3.4.

To achieve the highest probability of adequate reception, and in order that the receiver mute shall function efficiently, the field strength of the transmissions should not be subject to wide fluctuations with movement of receiving location. This requirement is influential in dictating the frequency which should be used.

3.2. Choice of frequency

Work so far endorses the opinion that frequencies above the MF band would not be suitable for the proposed service. The HF band is disregarded because the propagation characteristics are quite unsuited to the needs of a network of low-power stations requiring local and consistent coverage. With a VHF channel, although the median protection ratios available would be higher than those obtained at LF or MF, the larger variations of field strength with receiving location would produce wide local deviations about the median values. This wider field strength variation would also demand a low muting level (if reception is to be guaranteed) with a consequent increase in the reception of extraneous information. Furthermore it would probably be impossible to find a frequency either within, or adjacent to, the existing Band II spectrum for this service.

The use of frequencies above the VHF band is not considered here because of the further increase in local variation factor which would be incurred.

A frequency in the LF band does not appear suitable for the small areas required to be covered by each transmitter. This band would be more suited to a network of higher-power regional stations in which only one or perhaps two were required to operate simultaneously. In selecting an operating frequency in the LF/MF range an important factor which must be remembered is the local oscillator interference which could be created by ordinary car receivers. This would dictate the use of a frequency below about 600 kHz or between about 760 kHz and 975 kHz.

The best part of the radio spectrum that would seem to provide low fluctuation with vehicle movement is that between 500 kHz and 600 kHz. Also by going to the lower end of the MF band a better compromise between day and night-time interference is reached, particularly when unwanted sky-wave levels are generated solely within the traffic network, as will be seen later.

3.3. Calculations

For the purposes of calculation a possible practical arrangement for traffic information transmitters using 72 existing BBC sites has been drawn up and this is shown in Fig. 4. In the frequency range considered, local ground conductivity dictates that radiated powers should exceed 500 Watts in a few cases, although the average power would be nearer 250 Watts. A protection ratio of 18 dB has been deemed adequate because the service is needed to convey intelligence only and not entertainment. The following calculations give protected field strengths for the service areas when operating both in the day and at night. In this context it should be noted that sky-wave field strengths shown are those exceeded for 50% of the time. Inevitably, of course, the use of a medium frequency means that the coverage at night will be reduced by interference, but the majority of traffic problems occur during the day, when there is much less interference.

The first session of a Regional Administrative Broadcasting Conference, intended to prepare a plan for the LF and MF bands, took place in Geneva in October 1974. Until the second session is held (planned for October/November 1975), it is difficult to forecast the kind of assignment that might be obtained for a TDM traffic information service. However, in the calculations three alternatives have been assumed. Firstly, that a single frequency would be used exclusively for a motoring service in the U.K. and elsewhere in Europe. Secondly, that a TDM network in the U.K. would use a channel allocated for sharing by low-power transmitters. The Copenhagen plan provided two such channels, termed 'International Common Frequencies' (i.c.f.s.). Thirdly, that the U.K. traffic service would have to share a channel with high-power stations elsewhere.

A field strength of 70 dBμ* has been considered as the minimum to give a day time service. This choice is reaffirmed when the receiver design is considered later in the report.

Alternative 1 For the purposes of calculation, a frequency of around 600 kHz has been assumed to be dedicated exclusively to the TDM network.

Fig. 5 shows an example of the calculation to assess ground-wave, sky-wave and combined interference levels at one of a number of receiving test locations investigated. Table A lists the transmitters broadcasting in the same time slot, records their distance from the test location and by considering local ground conductivity, establishes the e.m.r.p.** for each interfering station. Table B lists under respective transmitter numbers the field strength for 1 kW over the interfering ground-wave path and takes into account overall ground conductivity and land/sea mixtures.

* In this report field strengths are quoted in dBμ, that is, decibels relative to 1 μV/m.

** Effective monopole radiated power. In this context this may be regarded as the transmitter power less power dissipated in the aerial and earth systems.

TRAFFIC INFORMATION SERVICE NETWORK

* Time Slot Number 2 Frequency: 593 kHz
Service Area : Dodford
Test Location : Northampton

TABLE A

Interfering Source	No.	D(km)	mho/m x 10^{-3}	EMRP for 30 km dB rel. 1 kW
Rampisham	1	208	10	–8
Bexhill	2	185	10	–8
Aldeburgh	3	174	10	–8

TABLE B

GROUND-WAVE				
No.	FS 1 kW dBμ	EMRP	Prot. Ratio	PFS dBμ
1	50	–8	+18	60
2	50	–8	+18	60
3	52	–8	+18	62
			$\sqrt{E^2}$	65

TABLE C

SKY-WAVE			
FS 1 kW dBμ	EMRP	Prot. Ratio	PFS dBμ
52·5	–8	+18	62·5
52·5	–8	+18	62·5
52·5	–8	+18	62·5
		$\sqrt{E^2}$	67

TABLE D

	dBμ
Day protected field strength	65
Night protected field strength $\sqrt{(\text{ground}^2 + \text{sky}^2)}$	69
Night interfering field strength level	51

* This term is used to identify the stations's position in the announcement sequence used in the group, assuming automatic switching is employed.

Fig. 5

The appropriate e.m.r.p. value and protection ratio are then added to give the protected field strength for each contribution; the resultant is shown at the bottom of the column. In Table C the sky-wave field strength exceeded for 50% of the time is derived in the same way; the interfering transmitters are assumed to have sites with good ground conductivity. Protected fields for day and night are shown in Table D, together with basic value of night-time field strength.

Fig. 6 is a summary list for an area with the greatest transmitter density, showing receiving test locations in each service area tabulated against individual levels of interference and 50% night-time field strengths.

The foregoing has assumed the network is confined to the United Kingdom. To obtain some idea of the result if this network were to be extended across Europe a near-infinite lattice has been assumed to be composed of transmitters having an average e.m.r.p. of 250 W (–6 dB with respect to 1 kW). Then, under these circumstances:—

Field strength of sky-wave in near-infinite lattice = 66 dBμ for 1 kW e.m.r.p.
= 60 dBμ for 250 Watts e.m.r.p.

U.K. Peripheral allowance* = –3 dB = 57 dBμ

* To take account of the advantages derived by the UK from its position on the Western boundary of Europe.

TRAFFIC INFORMATION SERVICE NETWORK
BASIC U.K. ONLY
SUMMARY LIST OF PROTECTED FIELD STRENGTHS FOR 593 kHz
NUMBER OF STATIONS PER GROUP = 16

Time slot* Number	Transmitter	Receiving test location	50% Night FS	PSF day dBμ	PSF Night dBμ
1	Droitwich	Stratford	51	65	69
2	Dodford	Northampton	51	65	69
3	Bournemouth	Lymington	49	60	67
4	Fareham	Ventnor	49	61	67
5	Sutton Coldfield	Kenilworth	53	67	71
5	Tatsfield	Crawley	52	62	70
5	Tatsfield	S.W. London	53	65	71
6	Leicester	Nuneaton	50	64	68
7	Salisbury	Andover	50	64	68
8	Guildford	Alton	49	62	67
9	Bristol	Chippenham	49	64	67
10	Swindon	Burford	52	64	70
10	Dolgelley	Aberdovey	53	68	71
11	Wrexham	Corwen	52	64	70
11	Wrexham	Whitchurch	52	64	70
12	Stoke-on-Trent	Macclesfield	50	61	68
13	Penmon	Llanrwst	51	65	69
13	Churchdown Hill	Evesham	52	64	70
14	Wallasey	Chester	49	62	67
15	Swansea	Llandilo	49	59	67
16	Brookmans Park	Luton	51	66	69

* Assumes simple sequential switching for interference purposes.

Fig. 6

Protected Ratio = +18 dB
Protected Field Strength = 75 dBμ

for 5 x 10^{-3} ms/m Day-time range = 30 km
Night-time range = 20 km

Additional stations in Europe would not effect the day-time protected fields and at night the mutual level throughout would be more or less uniform at 75 dBμ. In the absence of precise knowledge concerning the exact frequency, adjacent channel interference is not considered here.

Alternative 2 This would be to co-channel the U.K. network with transmitters using ICF assignments; 1 MHz has been taken as a likely frequency. Of course, because of the mode of operation, the maximum power required for such an assignment for the U.K. would only be five times the e.m.r.p. for one station, because never more than five stations are in simultaneous operation.

Cumulative multiple sky-wave from ICFs is about 60 dBμ at present.
With a protection ratio of +18 dBμ Protected field strength = 78 dBμ.

It is not known what protection would have to be given to transmitters on the Continent. For this calculation it will be assumed that a protection ratio of 30 dB would be required, and that the protected field strength, as determined by interference from the U.K. alone, must one exceed 84 dBμ. (This means that if the protected field strength were 90 dBμ in the absence of interference from the U.K., the latter would increase it to 91 dBμ.**) On this basis the resultant field strength in Europe due to the U.K. transmitters must not exceed 54 dBμ. Assuming five transmitters to operate simultaneously in the U.K., it is found that the radiated power of each should be restricted to 280 Watts. Then:

for a conductivity of 5 x 10^{-3} ms/m
Day-time range = 20 km
Night-time range = 10 km

for a conductivity of 1 x 10^{-3} ms/m
Day-time range = 7·5 km
Night-time range = 4·5 km

Certain stations near the south-east coast would be even further restricted in range.

** Power addition of two signals differing by 6 dB gives a resultant approximately 1 dB greater than the stronger signal.

Alternative 3 For a U.K. network to be co-channelled with normal services radiating from existing stations, a frequency near 500 kHz has been considered as an example. The various night-time protected field strength from sources sharing the channel are as follows:—

(a) Field strength in Central England from source 1 = 56 dBμ
Frequency 533 kHz, protection ratio 18 dB, protected field strength = 74 dBμ

(b) Field strength in Central England from source 2 = 66 dBμ
Frequency 527 kHz, protection ratio 10 dB, protected field strength = 76 dBμ

(c) Field strength in Central England from source 3 = 53 dBμ
Frequency 529 kHz, protection ratio 21 dB, protected field strength = 74 dBμ

From these results, multiple protected field strength = 80 dBμ. This could limit the night-time range of the TDM stations to about 13 km.

Dealing now with the interference which would be caused to these stations by the TDM network, existing protected field strengths are as follows:

Source 1 service area = 85 dBμ
Source 2 service area = 95 dBμ
Source 3 service area = 105 dBμ

To calculate the contribution of the TDM network, the latter is assumed to consist of five 500 W sources operating simultaneously from a point in Central England, that is, a combined e.m.r.p. +4 dB w.r.t. 1 kW. Then contributions are as follows:—

Service Area	Field Strength	Prot. Rat.	Prot. F.S.
Source 1	29 dBμ	30 dB	59 dBμ
Source 2	41 dBμ	22 dB	63 dBμ
Source 3	41 dBμ	33 dB	74 dBμ

A high degree of modulation compression at the transmitter was assumed when deriving the adjacent channel protection ratios.

From the results it will be seen that the introduction of the traffic information service may be neglected in terms of additional interference to existing services. Indeed, powers higher than 500 W could be used; for example if the radiated power of each transmitter were 2 kW, the predicted field strength of source 1 (the worst case) would be increased by only 0·2 dB.

It is very obviously very desirable that night-time interfering field strengths do not cause spasmodic mute operation. With a muting level of 70 dBμ, clearly Alternative 1 provides adequate protection. However, in the case of the other alternatives, interfering field strengths for 50% time between 60 dBμ and 66 dBμ could operate the mute on certain occasions at night. More work will be necessary to quantify this risk.

A possibility that has not been studied in detail is the use of a normal U.K. assignment, such as one of the frequencies now used for high-power transmissions. The objection to this course would be the vulnerability of the low-power transmissions to the introduction of unauthorised transmitters in Europe; to discourage these it would be necessary to radiate at least 25 kW from each transmitter, but the capital cost of all the transmitters would then be high.

3.4. Methods of network switching and operation

Assuming automatic operation, the simplest way in which to bring on each station in the separate groups or cells would be to transmit sequentially along and up the cell with individual automatic switching centres each sending control data. All control centres could be linked, so that if it became necessary to over-ride the sequence during an emergency, certain transmitters could be brought up with only a small reduction in co-channel protection. This might be accepted on infrequent occasions. Pre-determined inhibits between centres would prevent the worst situation occurring whereby certain adjacent transmitters were made to operate at the same time. Another solution to deal with emergencies has been suggested by the Transport and Road Research Laboratory whereby each 16 station cell is allocated 17 time slots, thus providing a spare time slot every cycle which could be used to operate the appropriate transmitter containing an emergency within its coverage. If the road situation was normal then the extra slot would merely pass as dead time. This system would provide a reserve of time to deal with an exceptionally heavy demand in one area, but it would not necessarily shorten the waiting time.

Thirdly, rather than employing 16 stations per cell 18 could be introduced with very little difference in overall interference levels and in an emergency the large cell could be switched to a 'double-nine' arrangement giving the system increased flexibility by increasing the chance of operating the station best situated to deal with an emergency. It is assumed that the increased interference could be accepted in an emergency.

A further arrangement is contained in the section dealing with the receiver and has been dictated by the probable need to introduce a time delay before the carrier controlled mute closes the receiver down.

Probably the best solution would be to have a system in which transmission was directed on demand from control centres. For example, each group would be controlled from a centre which would receive and co-ordinate the information, and would then select the transmitter serving the appropriate area. Links between control centres would guard against the risk of simultaneous transmission of stations within mutual interference range.

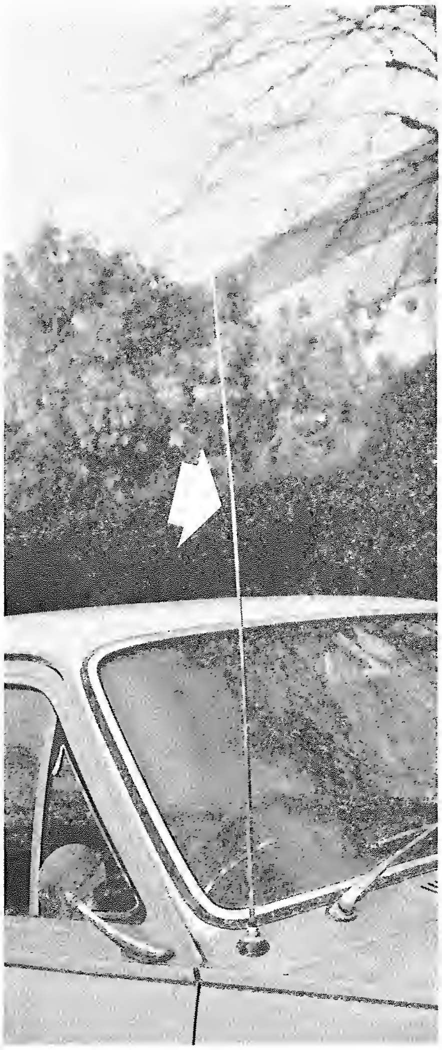
Fig. 7 - Car receiving aerials used during tests

(*a*) 1·18 metre vertical wing mounted whip

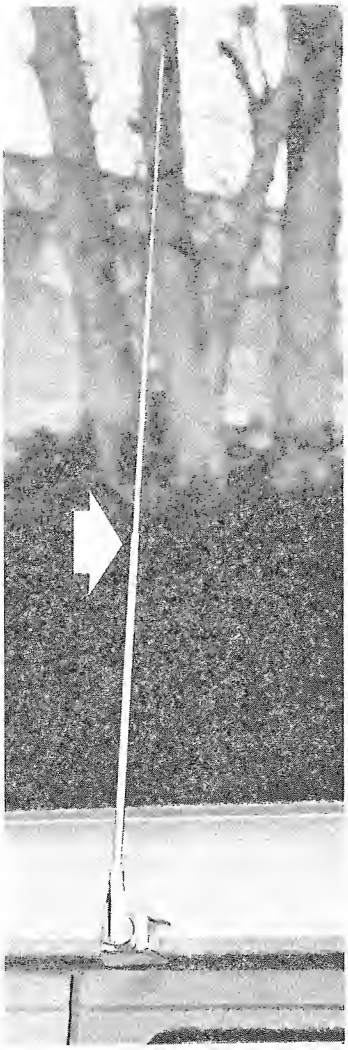
(*b*) 0·74 metre near-vertical gutter mounted whip

(*c*) 95 mm diameter Disc Aerial for internal windscreen mounting. (Also doubles as a licence holder.)

(*d*) 0·89 metre long aerial for horizontal internal windscreen mounting. (Also doubles as an anti-glare visor.)



(*a*)



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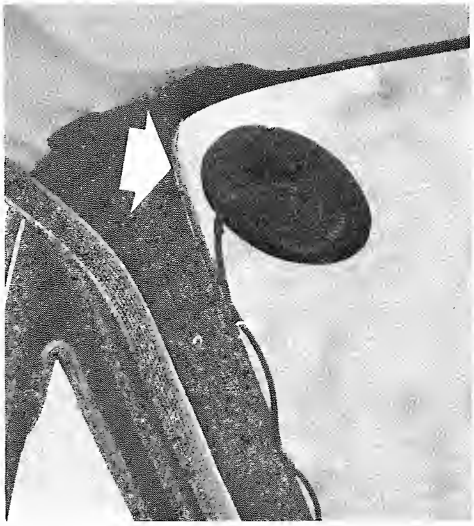
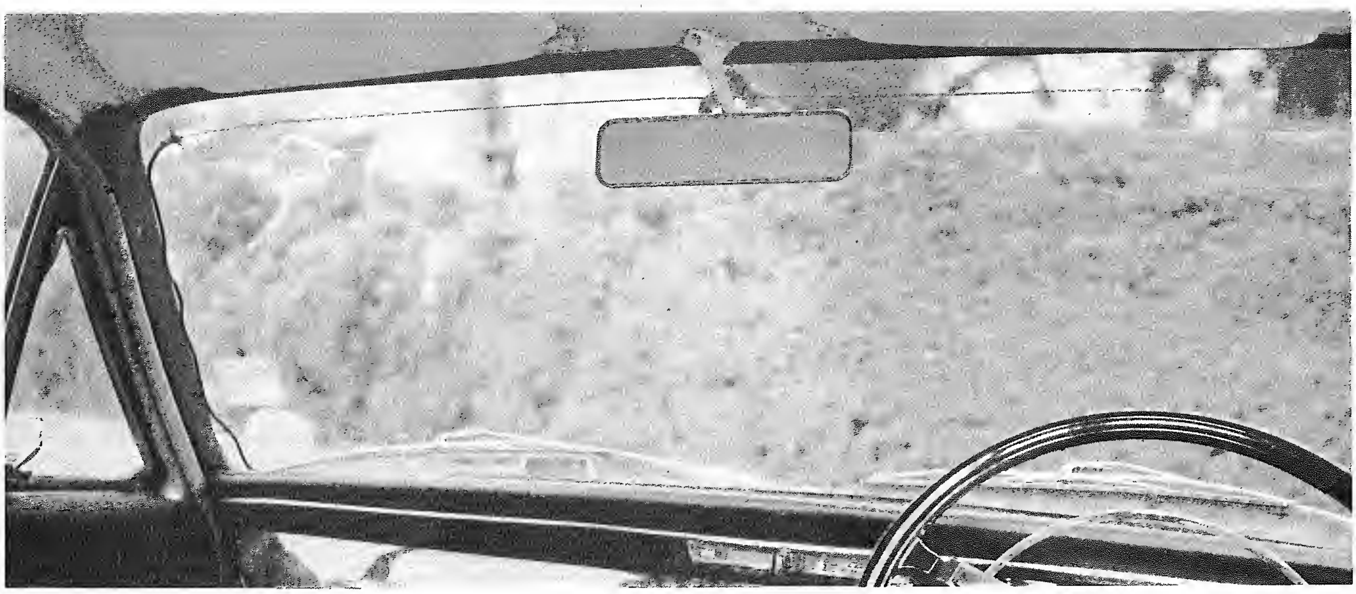


(*c*)



(*d*)

4. The receiver

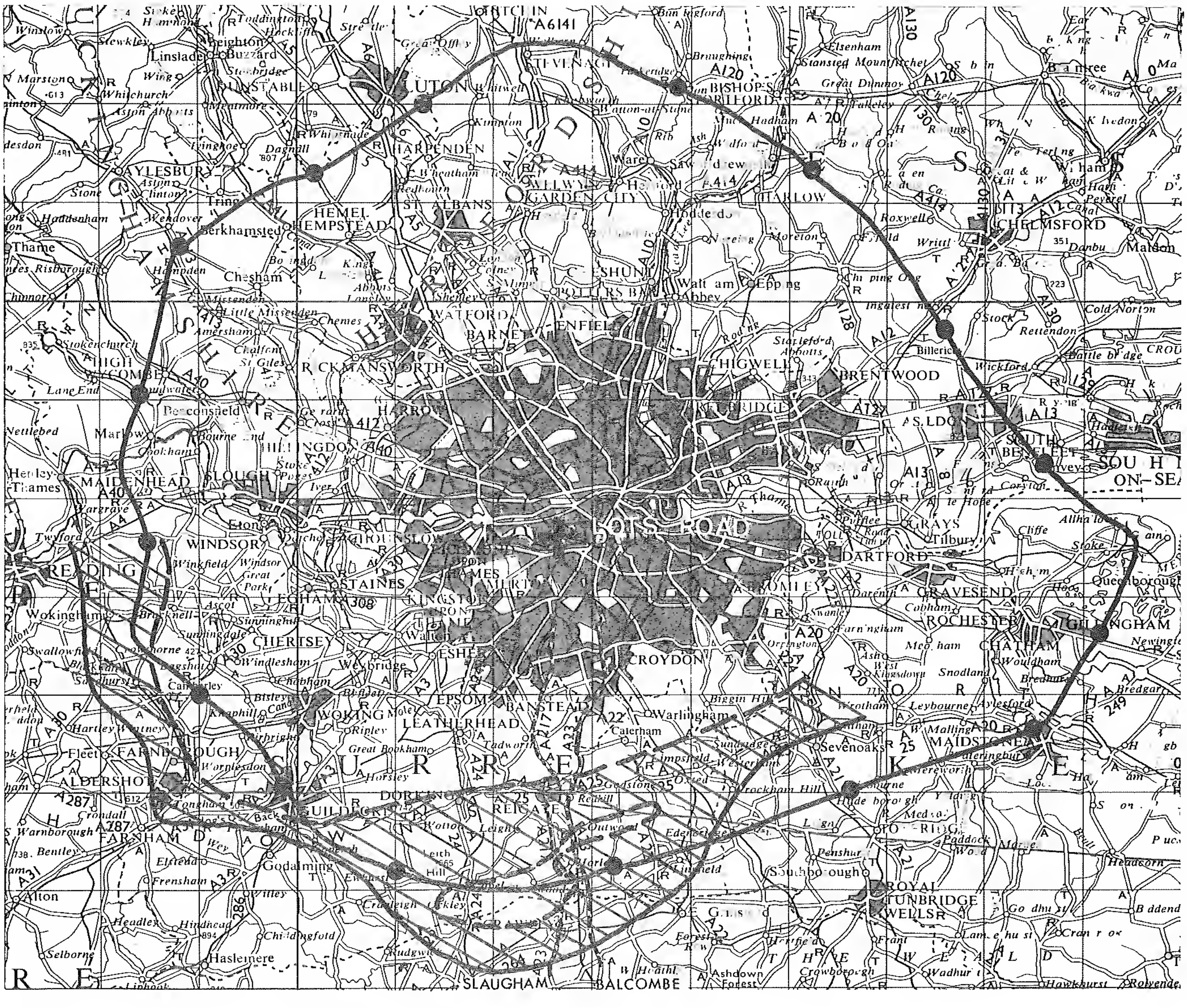
4.1. General

An important advantage of the time division multiplex proposal is that it operates on a single frequency and hence the motorist will not need to tune a separate receiver. Assuming the use of a frequency in the low part of the medium-wave band, a straight tuned radio frequency receiver could be employed, with consequent reduction in cost and avoidance of any interference created by a local oscillator. This could be very much cheaper than a medium-wave superheterodyne or v.h.f. car radio. Another advantage already mentioned is that the driver will receive only local information, i.e. relevant to the areas through which he is passing. Satisfactory working here will depend to a large extent on the system of car receiver muting adopted, and to assist with the specification of this important feature and to clarify other aspects a limited programme of field work was carried out.

4.2. Field work

4.2.1. Scope

In theory, it should be possible to move away from



557 kHz Lots Road
(Tx Power : 1 kW)

Key

M.P.T. measured 3 mV/m
Service limit (Mute permanently on)
Service limit (Mute commences operating spasmodically
Area where spasmodic operation is annoying

Fig. 8

an MF transmitter without significant loss of service, until the muting level field strength is reached. In practice, variations of field strength occur which can result in sporadic operation of the mute. This means that the boundary of the service area will be diffused and even within the limit, drop-outs may occur. The problems of irregular reception would, of course, be accentuated where a switching zone was common to two or more overlapping services, when mixed information might be heard with a confusing loss of continuity. Thus the primary objective of the field work was to establish the clarity with which the service limit could be defined when travelling along roads radial to the transmitter. Certain other items of interest emerged from the work and these are also discussed.

The majority of the field work was carried out using a Vauxhall Victor estate car. This was fitted with a prototype receiver* containing an adjustable mute. Various aerials were used in conjunction with the receiver, and their performances were compared. Illustrations of these aerials form Fig. 7. For the majority of tests, however, the receiver was fed by the gutter mounted telescopic whip aerial fixed on the nearside and calibrated against a 'Potomac Instruments' field strength meter. The mute threshold was set at 70 dBμ and would switch with only about $\pm 0{\cdot}25$ dB deviation.

For listening and measuring it was desirable to tune to a transmission at the low frequency end of the medium wave band, sited in the London area with about 500 Watts e.m.r.p. Thus the receiver was aligned to IBA 'Capital Radio', transmitting from the Lots Road site on a frequency of 557 kHz.

4.2.2. Definition of boundary

Initially a peripheral route was followed and an assessment made of the area where switching indecision caused unsatisfactory listening. Fig. 8 shows a mobile survey comprising a 120° sector from Reading to Sevenoaks and involving a journey through such marginal towns as Farnborough, Aldershot, Guildford, Crawley and East Grinstead. Three categories of reception are plotted. The region shown hatched indicates the extent of spasmodic mute operation, which could be annoying during traffic announcements. Working towards the transmitter from the inner and dotted contour the service may be considered as solid, if very short 'drop-outs' are ignored. Moving away from the outer contour the mute remains in permanent operation with no further reception.

Results obtained at this stage suggested that a more precise analysis was required if any recommendations were to be made about future receiver design.

Fig. 9 is an example of graphic information obtained by equipping the Vauxhall with a twin channel recorder running at 20 mm/minute. The chart shows field strength on the upper trace and mute drive level on the lower. A second aerial attached to the offside front wing was used to feed the recording meter, with no adverse effect on the performance of the gutter-mounted aerial, which continued to drive the receiver and provide muting data. Using this arrangement two 50 km radial journeys were undertaken, the first from Sutton to Slaugham and the second from Balcombe to Streatham (see routes on Fig. 8). Unfortunately in these preliminary trials shortage of time dictated that both radials ran in approximately the same direction from the transmitter. While both Slaugham and Balcombe are at the southerly extremes of the service area, i.e. mute had entered permanent operation, it was considered unnecessary to start close to the transmitter. Therefore, the overall transition from the maximum receivable signal to 70 dBμ was not fully investigated. However, to obtain a more accurate balance between 'on-time/off-time' and give a representative result for field strength with respect to percentage journey time, the duration of each radial was projected back to Lots Road. The extended times of 68 minutes and 70 minutes for outward and inward journeys

* BBC Research Department Report No. RD 1974/36.

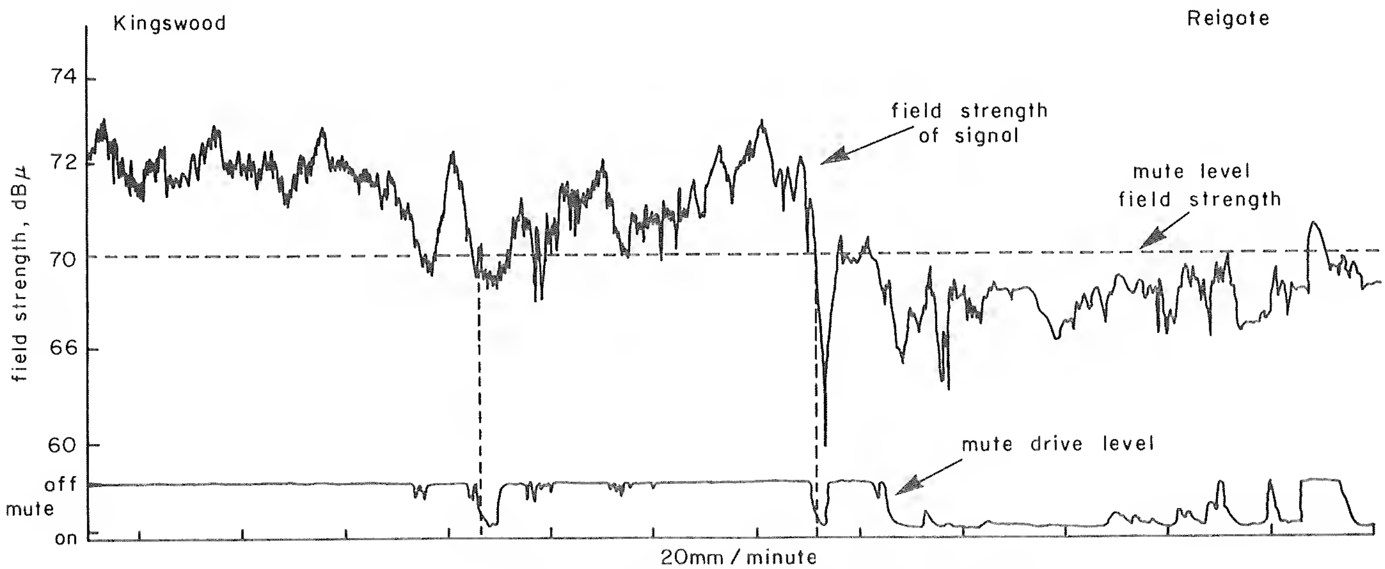


Fig. 9 - Chart recording of field strength of Capital Radio, 557 kHz

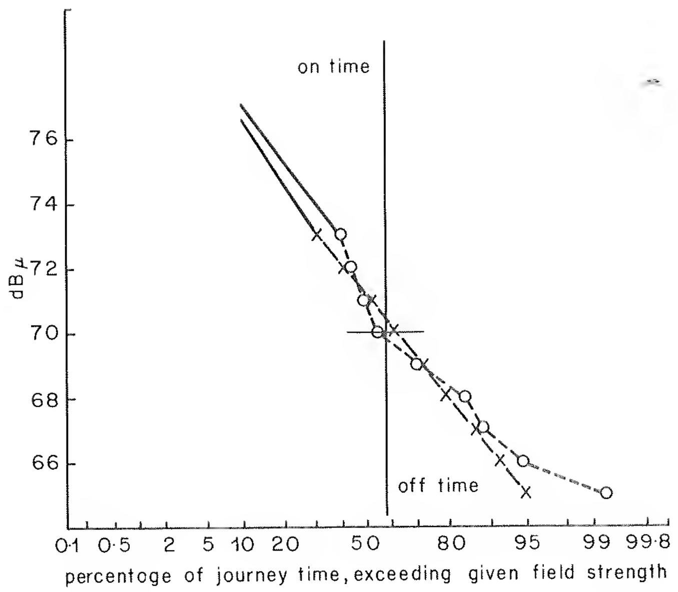


Fig. 10 - Analysis of chart recordings of Capital 557 kHz using a wing aerial on a Vauxhall estate car

O- - - -O Sutton (A217) to Slaugham
X———X Balcombe (B2036) to Streatham (A23)
——— Projected to Lots Road

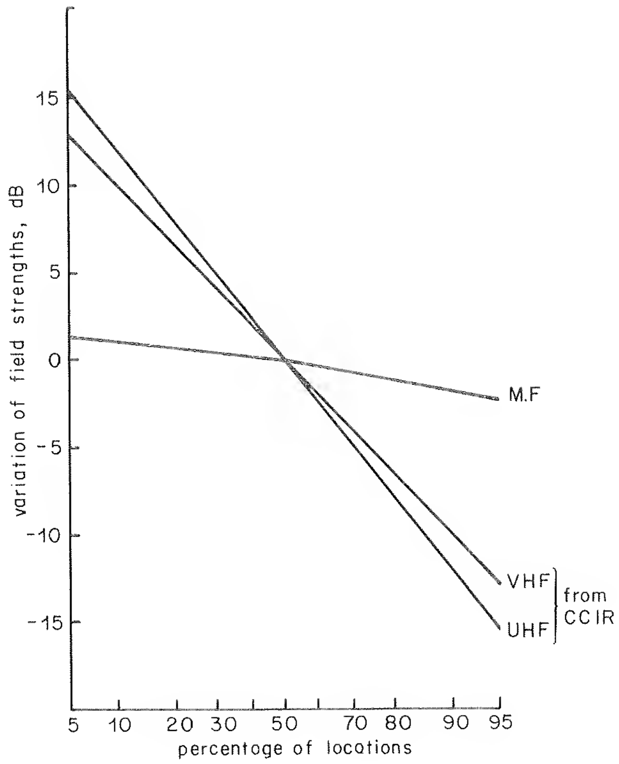


Fig. 11 - Variation of field strength, with respect to the median value recorded over areas of approximately one square kilometer

then became a basis for preparing the distribution given in Fig. 10. To assess the proportion of traffic which would be affected by intermittent operation it would be necessary to complete the contours and then determine traffic density within the areas. The radial assessment, however, does illustrate the situation. More extensive field trials now to be undertaken will examine this factor fully.

4.2.3. Effect of local variation on mute

In addition to macroscopic variations in field strength level which give rise to the boundary diffusion mentioned in the previous section, local variations could also cause spasmodic operation of the mute. Of course, as already mentioned, one of the reasons for selecting a low MF for this service is because the extent of local variations is low. Some investigation has already been carried out here, and this has produced the result shown in Fig. 11. These results have been compared with local variation factors for the VHF and UHF bands, and this reveals that in this respect, MF reception is, as expected, less susceptible to fluctuation with movement of the car.

4.2.4. Mute time constant

The variation of field strength and the response of the mute introduces the question of the mute time constant. The receiver under test had virtually no 'hold-on' capability and once the input voltage fell below the preset threshold the mute operated within about a second. If muting could be delayed for at least 10–15 seconds after the signal fell below the 70 dBμ threshold, then according to Fig. 12, the occurrence of total information loss would be substantially reduced as longer periods of signal reduction could be tolerated. With further reference to Fig. 10, local variation within the nominal service area seldom caused the median field strength to fall below 66 dBμ within the 'off-time'. As it is reasonable to expect the receiver a.g.c. to deal successfully with a fading range of 4 dB between 70 dBμ and 66 dBμ there should be no discernible audio impairment throughout an announcement. Further development work during a proposed field trial of the TDM system is expected to assist the design of the most suitable mute delay characteristic. It is pertinent to note at this point that the transmitter switching sequence might help the problem. If there is a risk that receiver lag will cause sporadic reception of adjacent areas in automatic operation the timing need not be sequential along and up a cell but be arranged as Fig. 13, thereby increasing the distance between transmitters operating consecutively.

At the risk of making the receiver slightly more expensive the addition of an amplitude latch could assist in smoothing out reception breaks once the mute has been lifted. For example if 70 dBμ continued to be the field needed to open the mute, thus retaining similar protection against unwanted signals, and a mute closeure level of 66 dBμ was adopted, then according to Fig. 10 the percentage 'on-time' would rise from 58% to about 93%. Unfortunately, a continuous transmission is unsuitable to test any such hysteresis system. Only by conducting tests with burst transmissions, typical of a TDM network, could the modification be properly appraised.

4.2.5. Conclusions from preliminary field work

The field trials so far completed have been too limited to resolve all the problems, and further work is

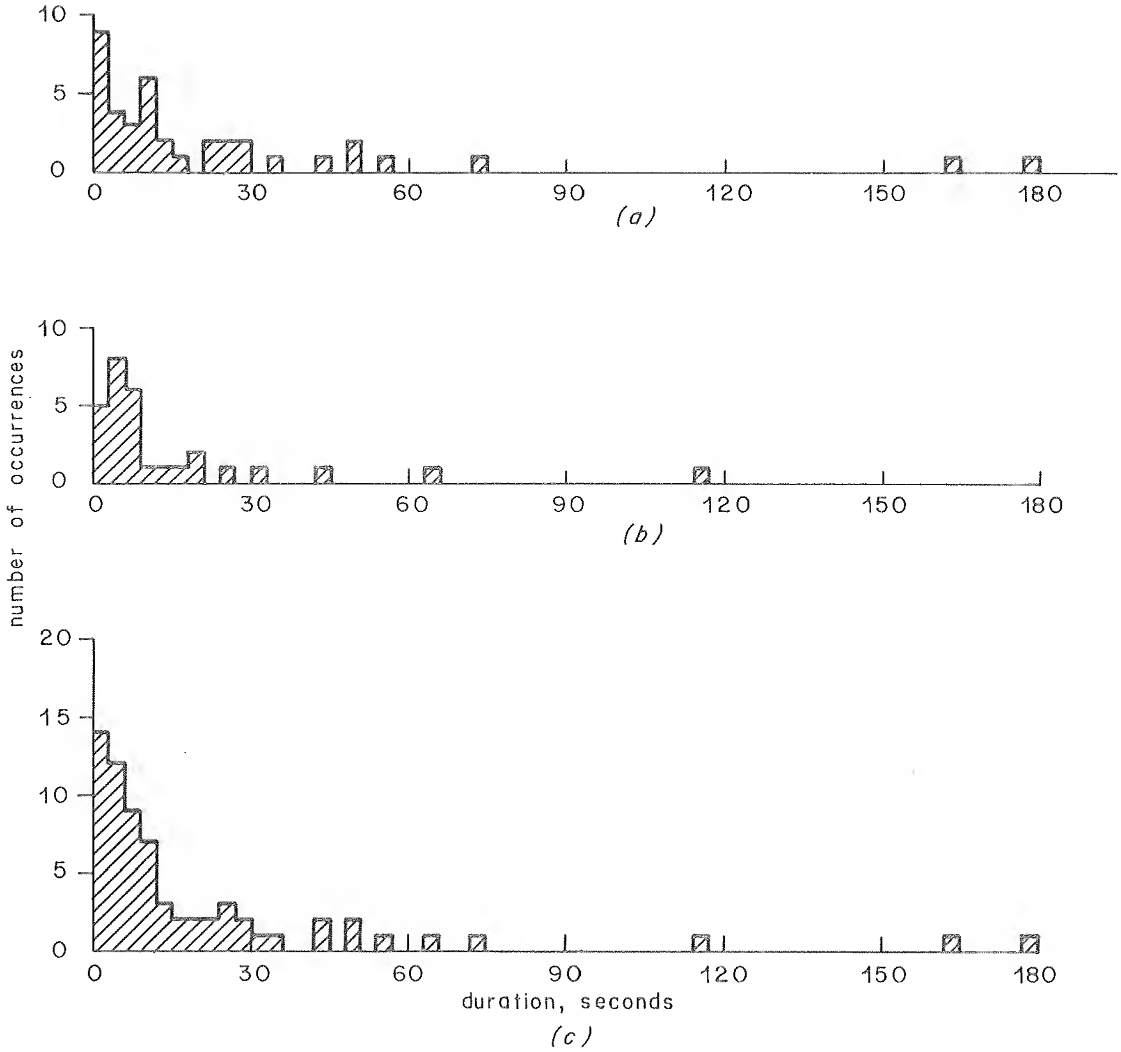


Fig. 12 - Occurrence and duration of receiver muting

(*a*) Sutton to Slaugham. Range 10·6 to 48·7 km (*b*) Balcombe to Streatham. Range 7 to 46·3 km (*c*) Combined

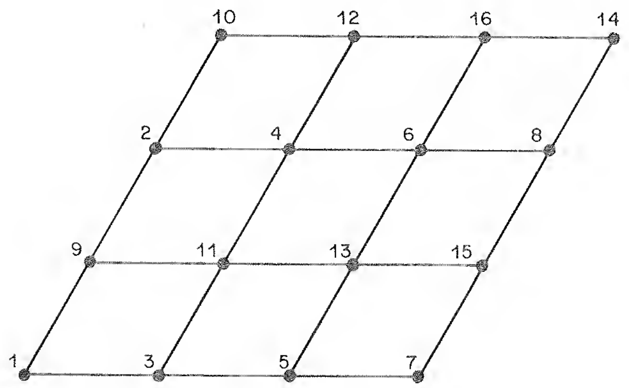


Fig. 13

essential. However, it is clear that the main difficulty at the receiving end is the specification of the mute. Time delay and amplitude latch techniques could help to sustain an announcement, but would do nothing to prevent a driver missing the opening or the entire transmission when his vehicle was in a local dead spot. The problem could be partially overcome by devoting the first few seconds of each announcement to a non-information period, which would give the mute an opportunity to lift and hold before details were transmitted. This period could be occupied with warning tones which would in any case be necessary to avoid alarming the driver by an unexpected burst of speech.

As a result of this preliminary work a more extensive test is now planned, and for this it is intended to operate a group of three or four transmitters, using TDM.

4.3. Other receiver features

So far it has been assumed that, initially at any rate, the special receiver would be additional to, and separate from any existing receiver in the car. In the absence of any switching arrangement to select output from either, the output from the traffic receiver would have to compete against that of the car receiver. For the prototype receiver it was assumed that the audio output would have to equal that of the car receiver's, thus a 5-watt amplifier driving a 155 mm x 104 mm elliptical loudspeaker was used. Adequate output (in the absence of another receiver) was obtained from an 800 mW cassette recorder, driving a much

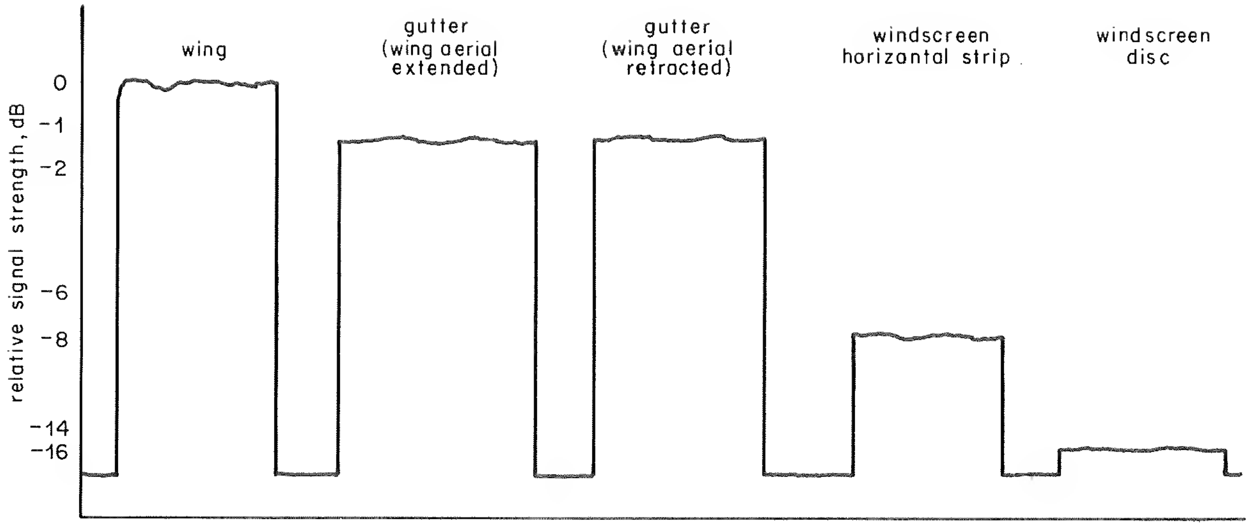


Fig. 14 - Horizontal radiation patterns of car aerials

smaller loudspeaker. To overpower other 'in-car' entertainment, however, such a speaker would have to be mounted close to the driver's head, possible positions being either clipped to a sun visor or suspended from a hook on a door column. The electronics required for the traffic receiver can be very compact, and if a large speaker is not needed the receiver could be quite small. Ultimately, of course, if the service proved to be successful, the receiver could form part of the normal car receiver, and provision for switching from one output to the other could be contained in audio signals incorporated in the traffic announcement. With such identification a more sophisticated receiver could also contain the ability only to operate when fed with a unique tonal code, thereby giving full protection against spurious intervention by unwanted stations if the channel were occupied by foreign high-power transmitters. A short frequency-selective finishing tone would also stop interfering stations from capturing the receiver at close-down. A further embellishment would be to use the identification signals preceding the announcements to prevent the reception of repeated messages or to code messages into various categories, say for heavy vehicles only. The receiver could then be fitted with an 'information select' control to enable drivers to listen to the type of announcement best suited to their need.

The mute must operate at a prescribed field strength level, therefore the special receiver, associated feeder and aerial should be supplied to the motorist as a calibrated package. Obviously, the installation should be as simple as possible, and the features of four cheap aerials have therefore been examined. Fig. 14 shows the relative gain and horizontal radiation pattern (HRP) of these aerials. The windscreen attached horizontal strip and licence holder disc aerials can both be discounted due to poor gain and dependence on the mounting position. It is likely that the prospective listener will already have a permanently-mounted wing or roof aerial and would be reluctant to make more holes in the body-work, therefore the clamp-on gutter aerial is through to form the best compromise. During the field trials tests showed there was no measurable coupling between the two external aerials.

A brief study was also made of the receiver input voltage variations for different gutter fixing positions on a number of cars, and most samples fell in a 1 dB to 2 dB range with a maximum scatter of 5 dB when going from one model to another. In view of this it would seem desirable to fit a control giving ±2·5 dB variation of mute level. The receiver dealer could then compensate for a range of installation sensitivity.

5. Discussion

This paper has given some details of a proposal to provide a motoring information service in the United Kingdom, using a network of low-power broadcast transmitters. It is beyond the scope of this paper to debate whether or not such a service is needed.* However, the investigation which has so far been carried out, together with associated work within EBU Sub-group K4, have served to clarify the role that broadcasting can play in serving the motorist. It will also ensure that any contribution supplements efforts being made by traffic specialists to provide other aids.

As far as broadcasting in the UK is concerned, there would seem to be four alternatives.

Firstly, the present services could be continued in their existing forms. The problems associated with these were outlined on the first page of this paper, and further elaboration is unnecessary. It is, however, emphasised that with the growth in the number of broadcasting stations the situation as far as the motorist is concerned is probably becoming more confusing. Which is his best source of information and how can he find it?

Secondly, without embarking on any ambitious new projects, it is possible to foresee changes of a programme

* In 1973 it was estimated that a 10% reduction in road accidents would save approximately £40 million per annum in the UK, and a reduction of one minute per hour of journey time would give a similar saving.

nature which could improve the present situation. For example, clearer distinction between national and local announcements with transmission on appropriate channels could be a step forward. It would also help if the number of outlets providing authoritative announcements could be reduced, but obviously such a suggestion ignores the competition which currently exists in broadcast services. Nevertheless, if traffic information is regarded as important, then it would seem desirable to do everything possible to improve the situation.

A third alternative would be to restrict the inclusion of the motoring information to one of the national VHF programmes. This would permit the use of the German proposal to give programme identification, but if such a course were adopted the amount of information which could be transmitted would not be any greater than is possible with the present arrangements, indeed, by confining it to the VHF band it might very well be less. Certainly the number of motorists who would be able to receive these transmissions would be a fraction of those who currently have a car radio becasue the great majority of such receivers in the United Kingdom, and indeed in Europe as a whole, are for LF/MF only. The problem of intrusion into programmes remains.

The use of VHF for a motoring service also raises a fundamental point concerning reception quality in cars. A VHF car receiver suitable for the German system will cost somewhere between £50 and £300 depending upon the degree of sophistication required. A motorist is not going to invest such a sum unless he is offered a very tangible return. Disregarding the unknown benefits of the motoring service, he will be promised better reception at VHF, but it is questionable if this can be fully appreciated in a motor car, where the ambient noise level may be as high as 80 dBA. Certainly stereophonic cassette recorders for motor cars are very much in the vogue, but these are not subject to problems created in the propagation path. Certainly, also, in normal domestic listening conditions the advantages of frequency modulation at VHF become obvious and this would seem to be a good reason for retaining these outlets for programmes designed for such listeners. The propagation problems which have been mentioned can be serious in the type of undulating terrain found in much of the United Kingdom, and the motorist may often need to retune his receiver; this is not an easy task for a driver. It would therefore seem unwise to initiate a service specifically designed for motorists using a Band II channel. Incidentally, it should be pointed out that the German proposal uses a subcarrier 57 kHz above the main carrier for identification purposes. At present various other proposals, including quadraphony and S.C.A.,* are being examined. It is unlikely that all these options can be accommodated in the sideband of a Band II service.

The fourth alternative is to introduce the TDM proposal. The advantages are as follows:—

(i) Equipment required by motorist is cheap.

(ii) Manipulation on the part of the driver is not required.

(iii) He is free to select any programme he wishes on his car radio, or to enjoy silence until an announcement is made.

(iv) Because it is local, there is an improved chance that the announcement, when it occurs, would be relevant.

(v) Because the announcement will be distinctive, he is more likely to hear and understand it.

(vi) There could be a substantial increase in the amount of information transmitted, with consequent benefits to traffic.

(vii) The proposal presents the opportunity to establish proper nationwide machinery between traffic authorities and broadcasters.

(viii) The transmitter network would be comparatively inexpensive.

(ix) If existing sites are used, then the service could be brought into operation quite quickly.

(x) The proposal is at the design stage, and hence could be planned to complement other developments which are intended to aid traffic.

(xi) Although a broadcasting system, it is economic in frequency usage.

In the context of (viii) and (ix) above, it is pertinent to note that although a full plan for the U.K. might require 70 or so stations, more than 80% of the country's traffic could be reached by about 20 stations. If the proposal will work, a limited network of this size would seem a very good investment.

Disadvantages of the proposal which are at present apparent are as follows:—

(i) It may be difficult to obtain a frequency sufficiently free from interference to ensure reliable operation everywhere at night.

(ii) There is a risk of erratic operation in fringe areas.

(iii) It does not meet some of the requirements put forward by the Radio Programme Committee of the European Broadcasting Union for such a service, e.g. a mutli-lingual service.

Dealing with the first disadvantage, from the initial examination it would seem that a solution is possible, at least on a temporary basis. If the proposal works, and is regarded as sufficiently important, then it is to be hoped that a frequency could be found for permanent operation. The problem of erratic operation in fringe areas needs further study, but if a complete solution cannot be found by receiver design, then it may be possible to diminish the effects by designing the network so that the fringe areas

* An auxiliary programme modulated onto a subcarrier.

fall, wherever possible, in places where traffic is light. In any case a fuller examination of the traffic situation than has so far been possible is certainly essential in order to ensure the best coverage in terms of traffic requirements is obtained. With regard to (iii), certainly the amount of information is such that multi-lingual transmission could not be handled, because sequential operation would be required, with a corresponding increase in programme time. It is conceivable that if adequate frequencies were available, then one might be allocated to each language. However, such a proposal, like many of those mentioned elsewhere in the context of traffic services, seems ambitious at this stage.

So far the TDM proposal has been kept as simple as possible in order to make it cheap and attractive to the motorist. However, there is little doubt that various refinements could improve the admittedly crude set-up at present proposed. Whether or not such improvements are practicable is a matter which cannot be answered until a field trial has been carried out and further discussions have been held with interested bodies, including receiver manufacturers. A field trial is any case essential, because only by this means can various aspects of the receiver design be resolved.

The work so far suggests that the principal difficulty in establishing any broadcasting system for traffic information is the gathering of information, and in particular, the interface between the traffic authorities and the broadcaster. If a TDM network is to be constructed, then it will be essential to institute control centres which would receive, classify and transmit the information, as well as maintain liaison with adjacent control centres servicing other parts of the network. Such centres could receive information from all reliable sources, and would soon build up valuable expertise to allow them to operate the TDM network to the best effect. A model of such an organisation is presently to be found in the BBC Motoring Unit, where the employment of ex-Police Officers ensures expert and sympathetic treatment of the information.

This paper has concentrated upon the requirements of the United Kingdom. A great deal of information has been acquired, however, which in due course will allow assessments to be made of the situation elsewhere in Europe. Although a standard traffic information system for use throughout Europe would seem to be a remote objective, much of the work will be considerably simplified if the objectives in each country can be clearly identified. Differences here may inevitably mean that a standardised system is neither feasible nor desirable.

Acknowledgements

The authors acknowledge the many useful discussions which have been held with engineers of the Transport and Road Research Laboratory, and with the Metropolitan Police. Co-operation from the BBC Motoring Unit and with members of BBC Local Radio is also gratefully acknowledged.

Appendix 1

Traffic Announcements from Local Radio Stations

1. Oxford

6 spots, 2/3 minutes between 6 am – 9 pm = 18 minutes maximum per weekday. Also at 5.15 pm, RAC live announcements for up to 2 minutes.

Maximum time/weekday with routine information = 20 minutes.

2. London

24 spots per day, one every ½ hour each lasting about 2 minutes. A member of Radio London is on duty at the Met. Police traffic control centre 12 hours each weekday and announcements are unscripted.

Maximum time each weekday with routine information = 50 minutes to 1 hour.

3. Medway

7 spots per day each lasting between 1½/2 minutes. An average coverage of 1 minute is also given on each news bulletin every hour on the half-hour 12 times a day.

Maximum time devoted per weekday 25 minutes to ½ hour.

With effect from October 1974 the AA will make the following unscripted contributions throughout the winter.

Weekdays	7/day each lasting 1/1½ mins.
Saturdays	6/day each lasting 1/1½ mins.
Sundays	2/day each lasting 1/1½ mins.

General

All information received is transmitted and the length of announcement is tailored to fit amount. For any major accident schedules would be changed and programmes interrupted.

SMW/VK

Appendix 2

BBC Motoring Unit JULY 1974

Date	Meteorological Office Information	MOTORWAY POLICE			OTHER ROADS POLICE		
		Fog	Ice Snow Floods Winds	Accidents Repair Congestion	Fog	Ice Snow Floods Winds	Accidents Repair Congestion
Mon. 1st	1		11	11		5	31
Tues. 2nd	1		8	17		2	25
Wed. 3rd	3		2	18			35
Thurs. 4th	1			16		4	20
Fri. 5th	3	4	2	3		2	39
Sat. 6th	1		1	9			15
Sun. 7th	2			1			8
Mon. 8th				15			14
Tues. 9th				9			23
Wed. 10th	1		4	15	1	1	21
Thurs. 11th	2		2	6			29
Fri. 12th	1			12			8
Sat. 13th	4	1		3			19
Sun. 14th	1	1		6			7
Mon. 15th	1		5	7			21
Tues. 16th	1	4	2	11	2		31
Wed. 17th	1		1	12			22
Thurs. 18th	1			11			29
Fri. 19th	1			17			23
Sat. 20th	1			9			32
Sun. 21st	2		1	1			9
Mon. 22nd	2		1	7			27
Tues. 23rd	1			7			17
Wed. 24th	2			5		1	24
Thurs. 25th	2			12			24
Fri. 26th	2			19			22
Sat. 27th	2			9			15
Sun. 28th	1						6
Mon. 29th				7			27
Tues. 30th	1			17			28
Wed. 31st.	1		1	2		4	38
	43	10	41	294	3	19	689
	43		345			711	

TOTAL 1099

Radio 1	–	238
Radio 2	–	282
Radio 1/2	–	422
Radio 3	–	0
Radio 4	–	157
		1099

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